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NOTES ON SOME SPECIES OF COLEOSPORIUM—II

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(WITH PLATES 22 AND 23)

COLEOSPORIUM IPOMOEAE

Coleosporium ipomoeae (Schw.) Burrill was first described in the uredinial stage by Schweinitz[1] in 1822, as *Uredo ipomoeae;* Burrill[2] in 1885 described the telial stage and placed the fungus in the genus *Coleosporium.* The aecial stage was discovered by the senior writer near Luray, Va., on *Pinus echinata* in 1914, and it was described[3] and the proof of its connection with the uredinial and telial stages was published in a brief note in 1917.[4]

Inoculations with *Coleosporium ipomoeae* have been made during 1915 to 1919 as follows:

Sixteen sets of inoculations were made with aeciospores from aecia on *Pinus echinata* collected from the following localities: Mont Alto, Pa; Luray and Petersburg, Va.; Asheville, N. C.; Etowah, Tenn.; Clearwater and Columbia, S. C.; Atlanta, Columbus, and Macon, Ga.; Auburn and Selma, Ala.; and Texarkana, Ark. Plants as follows were inoculated: 1 *Amsonia ciliata,* 2 *Aster conspicuus,* 1 *A. longifolius,* 3 *Calonyction acu-*

1 Schweinitz, L. D. Synopsis fungorum Carolinae superioris. Schr. Nat. Ges. Leipzig 1: 70. 1822.

2 Burrill, T. J. Parasitic fungi of Illinois. Bulletin Illinois State Laboratory 2: 217, 218. 1885.

3 Hedgcock, Geo. G., & Hunt, N. Rex. New species of *Peridermium.* Mycologia 9: 239, 240. 1917.

4 Hedgcock, Geo. G., & Hunt, N. Rex. The Peridermium belonging to *Coleosporium ipomoeae.* Phytopathology 7: 67. 1917.

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leatum, 6 *C. grandiflorum*, 1 *Chrysopsis mariana*, 2 *Convolvulus arvensis*, 13 *C. repens*, 11 *C. sepium*, 1 *Coreopsis verticillata*, 1 *Elephantopus carolinianus*, 2 *E. tomentosus*, 1 *E. nudatus*, 1 *Helianthus angustifolius*, 2 *H. decapetalus*, 3 *H. divaricatus*, 1 *H. radula*, 12 *Ipomoea batatas*, 2 *I. caroliniana*, 18 *I. lacunosa*, 16 *I. pandurata*, 5 *I. triloba*, 2 *Laciniaria elegans*, 3 *L. graminifolia*, 4 *Pharbitis barbigera*, 7 *P. hederacea*, 14 *P. purpurea*, 11 *Quamoclit coccinea*, 6 *Q. quamoclit*, 1 *Silphium simpsonii*, 1 *S. terebinthinaceum*, 1 *Solidago canadensis*, 1 *S. fistulosa*, 1 *S. rugosa*, 1 *S. multiradiata*, 1 *Vernonia glauca*, and 1 *Verbesina virginica*. Of these the following were infected, bearing mature uredinia in 14 to 18 days and mature telia in about 2 months: 14 *Ipomoea lacunosa*, 8 *I. pandurata*, 3 *Pharbitis barbigera*, and 4 *Quamoclit coccinea*.

Seven sets of inoculations were made from aeciospores from aecia on *Pinus palustris* collected in the following localities: Clearwater, S. C.; Brooksville, Gainesville, New Smyrna, and Ocala, Fla. Plants as follows were inoculated: 4 *Calonyction aculeatum*, 1 *Chrysopsis mariana*, 2 *Convolvulus arvensis*, 1 *C. sepium*, 3 *Ipomoea caroliniana*, 3 *I. lacunosa*, 5 *I. pandurata*, 10 *Laciniaria elegans*, 2 *L. elegantula*, 15 *L. gracilis*, 3 *L. pycnostachya*, 2 *L. tenuifolia*, 4 *L. graminifolia*, 6 *Pharbitis purpurea*, 4 *Quamoclit coccinea*, and 1 *Verbesina virginica*. The following plants were infected, bearing mature uredinia in 15 to 20 days and mature telia in about 2 months: 2 *Ipomoea lacunosa* and 5 *I. pandurata*.

Six sets of inoculations were made with aeciospores from aecia on *Pinus taeda* collected from the following localities: Atlanta and Macon, Ga.; Clearwater and Columbia, S. C.; and Petersburg, Va. Plants as follows were inoculated: 3 *Calonyction aculeatum*, 4 *C. grandiflorum*, 1 *Convolvulus arvensis*, 3 *C. repens*, 7 *C. sepium*, 1 *Coreopsis major*, 2 *Elephantopus tomentosus*, 1 *Helianthus angustifolius*, 2 *H. divaricatus*, 3 *Ipomoea batatas*, 6 *I. caroliniana*, 8 *I. lacunosa*, 3 *I. pandurata*, 5 *I. triloba*, 2 *Pharbitis barbigera*, 3 *P. hederacea*, 9 *P. purpurea*, 5 *Quamoclit coccinea*, 3 *Q. quamoclit*, 1 *Solidago fistulosa*, 1 *S. juncea*, 2 *Verbesina virginica*, and 1 *Vernonia glauca*. The following plants

were infected bearing mature uredinia in 14 to 18 days, and mature telia in about 2 months: 2 *Ipomoea caroliniana,* 1 *I. lacunosa,* 3 *I. pandurata,* 1 *I. triloba,* 1 *Pharbitis barbigera,* 2 *P. hederacea,* and 3 *Quamoclit coccinea.*

In the foregoing experiments all plants of species of *Calonyction* and *Convolvulus* failed of infection, although the majority were in prime growing condition. The plants of *Calonyction aculeatum* were grown from seed from a plant heavily infected with the rust in nature.

Coleosporium ipomoeae is known to occur in its aecial stage in nature on six species of pine. In this stage its range is from Pennsylvania to Florida and Texas. It is now reported for the first time on *Pinus caribaea* from Florida. In its uredinial and telial stages it occurs over a much wider territory, ranging from New Jersey and Kansas on the north to Florida and Texas on the south. In these stages it is found on species of *Calonyction, Convolvulus, Ipomoea, Pharbitis,* and *Thyella.* It has been successfully inoculated by the writers on *Ipomoea caroliniana, I. lacunosa, I. pandurata, Pharbitis barbigera, P. hederacea,* and *Quamoclit coccinea.*

The two most common and susceptible host species for the uredinial and telial stages of *Coleosporium ipomoeae* are *Ipomoea pandurata* and *Pharbitis barbigera,* of which the former has a much greater range. The most common and susceptible host species for the aecial stage is *Pinus echinata.*

COLEOSPORIUM RIBICOLA

Coleosporium ribicola (Cooke and Ellis) Arthur was first described in the uredinial stage by Cooke and Ellis[5] in 1878, as *Uredo ribicola.* The telial stage was described by Prof. Arthur[6] in 1907, and the fungus assigned to the genus *Coleosporium.* Dr. Long[7] discovered and described the aecial stage and proved its connection with the *Coleosporium* in 1916.

[5] Cooke, M. C., & Ellis, J. B. New Jersey Fungi. Grevillea **6**: 86. 1878.

[6] Arthur, J. C. North American Uredinales **7**: 86. 1907.

[7] Long, W. H. The aecial stage of *Coleosporium ribicola.* Mycologia **8**: 309–311. 1916.

The following inoculations have been made with *Coleosporium ribicola:*

During 1917, three sets of inoculations were made with aeciospores from aecia collected on *Pinus edulis* at Poncha by E. Bethel and the writer, and at Stonewall, and Trinidad, Colo., by E. L. Johnston and the senior writer. The following plants were inoculated: 1 *Grossularia inermis* (Rydb.) Cov. & Britt., 5 *Ribes aureum* Pursh., 1 *R. malvaceum* Sm., 2 *R. nigrum* L., and 2 *R. odoratum* Wendl. Of these plants, 2 *R. aureum* were infected with the rust, bearing uredinia in 14 to 16 days.

June 22, 1918, aeciospores from aecia collected by E. Bethel and the junior writer, June 15, on *Pinus edulis* near Del Norte, Colo., were used to inoculate the following plants: 1 *Grossularia hirtella* (Michx.) Sprach., 1 *G. inermis,* 1 *G. innominata* Jancz., 1 *G. leptantha* (A. Gray) Cov. & Britt., 2 *G. missouriensis* Nutt., 1 *G. reclinata* (L.) Mill., 3 *Ribes alpinum* L., 2 *R. americanum* Mill., 2 *R. aureum,* 4 *R. inebrians* Lindl., 4 *R. nigrum,* 10 *R. odoratum,* and 4 *R. vulgare* Lam. Of these plants, the following became infected, bearing mature uredinia in 14 to 16 days and telia by August 1: 1 *Grossularia hirtella,* 1 *G. inermis,* 1 *G. innominata,* 1 *G. leptantha,* 1 *G. missouriensis,* 1 *G. reclinata,* 4 *Ribes inebrians,* 1 *R. nigrum,* 3 *R. odoratum,* and 3 *R. vulgare.*

The following additional species have been infected by inoculation with urediniospores: 1 *Grossularia divaricata* (Dougl.) Cov. & Britt., and 1 *Ribes fasciculatum* S. & Z.

October 13, 1916, sporidia from telia collected by the senior writer on *Ribes aureum* at Denver, Colo., were used to inoculate the needles of the following species of pine: 1 *Pinus caribaea,* 7 *P. edulis* Engelm., 1 *P. bungeana* Zucc., 1 *P. girardiana* Wall., 1 *P. mayriana* Sudw., 1 *P. monophylla* Torr. & Frem., 1 *P. pinea* L., 2 *P. rigida,* 1 *P. serotina,* 3 *P. strobiformis* Sudw., 3 *P. strobus,* 3 *P. taeda,* and 6 *P. virginiana.* Of these trees, 4 *P. edulis* and 1 *P. pinea* were infected, bearing numerous pycnia December 16, 1917, and very sparse aecia February 28, 1918.

Coleosporium ribicola in its aecial stage resembles very closely in gross morphology *Coleosporium ipomoeae,* and since the two

species may have a common host in the north central United States, a comparison of the two species is now given:

Coleosporium ipomoeae

Pycnia conspicuous in single extended rows on chlorotic spots in leaves, olivaceous-black to brownish-black when old, 0.4 mm. wide by 0.7 mm.[8] long (Pl. 22, fig. 1).

Aecia in single extended rows, flattened rhomboidal, rupturing apically, 0.7 mm. high by 1.6 mm. long (Pl. 22, fig. 1).

Aeciospores 19 by 26 μ with walls 1.5 μ thick.

Peridial cells 22 by 42 μ with walls 5 μ thick.

Coleosporium ribicola

Pycnia conspicuous in single short rows on chlorotic spots in leaves, hazel to chestnut-brown when old, 0.4 mm. wide by 0.7 mm.[9] long (Pl. 22, fig. 2).

Aecia in single short rows, flattened rhomboidal, rupturing apically, 1.3 mm. high by 2 mm. long (Pl. 22, fig. 2).

Aeciospores 18 by 30 μ with walls 3.5 μ thick.

Peridial cells 23 by 26 μ with walls 4 μ thick.

Coleosporium ribicola, according to our records, has been collected as follows in the United States:

O and I on Pinus:

P. edulis: Colorado and New Mexico.

II and III on Grossularia and Ribes:

Grossularia cynosbati (L.) Mill: Minnesota and Wisconsin.

G. inermis: Colorado, New Mexico, Utah, and Wyoming.

G. leptantha: Colorado and New Mexico.

G. reclinata: Colorado, Minnesota, and Wisconsin.

G. setosa (Lindl.) Cov. & Britt: Wyoming.

Ribes americanum: Colorado and Wisconsin.

R. aureum: Colorado, New Mexico, Minnesota, South Dakota, Utah, and Wyoming.

R. coloradense:[10] Colorado, New Mexico, and Utah.

R. inebrians (includes *R. pumilum* Nutt.): Arizona, Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming.

R. mescalerium Cov: New Mexico.

R. montigenum McCl: Colorado.

R. odoratum: Colorado, Minnesota, New Mexico, and Utah.

R. sanguineum: Minnesota.

R. wolfii: Colorado and New Mexico.

[8] For *C. ipomoeae* in each case 100 measurements are given from 10 collections, 4 on *Pinus echinata,* 2 on *P. rigida,* and 2 on *P. taeda.*

[9] For *C. ribicola* in each case 10 measurements from one collection on *Pinus edulis* are given.

[10] Credit should be given to Professors E. Bethel and A. O. Garrett for many collections of this rust from the Rocky Mountain region.

Coleosporium ribicola has been successfully inoculated on *Pinus edulis, P. pinea, Grossularia divaricata, G. hirtella, G. reclinata, G. inermis, G. innominata, G. missouriensis, Ribes americanum, R. aureum, R. fasciculatum, R. inebrians, R. nigrum, R. odoratum,* and *R. vulgare.*

The specimens of *Coleosporium ribicola* from Minnesota and Wisconsin were collected in 1917 to 1919. The rust, although sparse, was widely disseminated in Wisconsin in 1918. No aecial host for the rust in these two states has been found, nor is the reason known for its sudden appearance in 1917, and apparent disappearance since 1919.

COLEOSPORIUM SOLIDAGINIS

Coleosporium solidaginis (Schw.) Thüm. was first described in the uredinial stage by Schweinitz[11] in 1822. The telial stage was described by von Thümen[12] in 1878 and the fungus assigned to the genus *Coleosporium.* The aecial stage was described by Underwood and Earle[13] in 1896 and called *Peridermium acicolum.* Proof that this *Peridermium* is the aecial stage of *Coleosporium solidaginis* was published by Dr. Clinton[14] in 1907.

In 1906,[15] Arthur and Kern described *Peridermium montanum* as a new species on *Pinus contorta* from the northwestern United States and Canada. The senior writer in 1914[16] infected *Aster* with this species, and Weir and Hubert in 1915[17] infected species of *Aster* and *Solidago* with it, and this species was assigned to *Coleosporium solidaginis.*[16]

11 Schweinitz, L. D. Synopsis fungorum Carolinae superioris. Schr. Nat. Ges. Leipzig 1: 70. 1822.

12 von Thümen, F. New Species of American Uredineae. Bul. Torrey Club 6: 216. 1878.

13 Underwood, L. M., & Earle, F. S. Notes on the Pine Inhabiting Species of Peridermium. Bul. Torrey Club 23: 400. 1896.

14 Clinton, G. P. *Peridermium acicolum* the aecial stage of *Coleosporium solidaginis.* Science, N. S. 25: 289. 1907.

15 Arthur, J. C., & Kern, F. D. North American Species of Peridermium. Bul. Torrey Club 33: 413. 1906.

16 Hedgcock, G. G. Identity of *Peridermium montanum* with *Peridermium acicolum.* Phytopathology 7: 64, 67. 1916.

17 Weir, J. R., & Hubert, E. E. Inoculation Experiments with *Peridermium montanum.* Phytopathology 6: 68, 70. 1916.

Inoculations as follows have been made with the aeciospores of *Coleosporium solidaginis* from 1913 to 1921:

Fourteen sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus echinata* from Mont Alto, Pa.; Petersburg, Va.; Biltmore, Black Mountain, and Marion, N. C.; Etowah, Tenn.; Columbia, Greenville, and Florence, S. C.; Gainesville and Macon, Ga.; Opelika, Ala.; and Meridian, Miss. Plants as follows were inoculated: 2 *Aster cordifolius,* 2 *A. conspicuus,* 2 *A. geyeri,* 2 *A. laevis,* 8 *A. macrophyllus,* 6 *A. paniculatus,* 1 *A. undulatus,* 5 *Chrysopsis mariana,* 6 *Elephantopus tomentosus,* 1 *Helianthus occidentalis,* 2 *Ipomoea fistulosa,* 1 *I. pandurata,* 1 *Laciniaria acidota,* 3 *Parthenium integrifolium,* 4 *Pharbitis purpurea,* 5 *Solidago bicolor,* 1 *S. chapmanii,* 5 *S. fistulosa,* 1 *S. hispida,* 2 *S. juncea,* 16 *S. multiradiata,* 2 *S. riddellii,* 5 *S. rugosa,* 4 *S. serotina,* 1 *S. speciosa,* 1 *S. squarrosa,* 4 *Vernonia flaccidifolia,* 5 *V. glauca,* 2 *V. noveboracensis,* and 4 *Verbesina virginica.* Of these plants, only those of *Solidago* were infected as follows: 1 *Solidago bicolor,* 1 *S. fistulosa,* 2 *S. juncea,* 16 *S. multiradiata,* 3 *S. rugosa,* 3 *S. serotina,* 1 *S. speciosa,* and 1 *S. squarrosa.* Mature uredinia were formed in 14 to 20 days, and mature telia in 2 to 3 months.

Seventeen sets of inoculations were made with aeciospores collected on the needles of *Pinus rigida* from Pleasantville, N. J.; Cold Spring Harbor, N. Y.; Caledonia, Greenwood Furnace, and Mont Alto, Pa.; Sugar Grove, O.; Harpers Ferry, W. Va.; Bluemont and Roanoke, Va.; Takoma Park and Washington, D. C.; and Black Mountain, Hot Springs, and Fayetteville, N. C. Plants as follows were inoculated: 2 *Aster acuminatus,* 10 *A. conspicuus,* 10 *A. cordifolius,* 3 *A. divaricatus,* 2 *A. dumosus,* 5 *A. ericoides,* 9 *A. geyeri,* 1 *A. hesperius,* 1 *A. laevigatus,* 2 *A. lentus,* 2 *A. lowrieanus,* 4 *A. macrophyllus,* 4 *A. paniculatus,* 2 *A. patens,* 1 *A. puniceus,* 1 *A. salicifolius,* 1 *A. undulatus,* 1 *A. vimineus,* 1 *Coreopsis tinctoria,* 1 *C. verticillata,* 4 *Elephantopus carolinianus,* 8 *E. tomentosus,* 1 *Helianthus occidentalis,* 3 *Parthenium integrifolium,* 1 *Senecio aureus,* 1 *S. obovatus,* 6 *Solidago bicolor,* 1 *S. caesia,* 27 *S. canadensis,* 1 *S. chapmanii,* 1 *S. erecta,* 4 *S. fistulosa,* 18 *S. juncea,* 19 *S. multiradiata,* 1 *S.*

neglecta, 4 *S. nemoralis*, 6 *S. riddellii*, 1 *S. rigida*, 7 *S. rugosa*, 3 *S. sempervirens*, 4 *S. serotina*, 3 *S. speciosa*, 11 *S. squarrosa*, 1 *S. tortifolia*, 1 *Vernonia blodgettii*, 7 *V. flaccidifolia*, 2 *V. glauca*, and 6 *V. noveboracensis*. Of these plants, only those of *Solidago* were infected as follows: 2 *S. bicolor*, 18 *S. canadensis*, 1 *S. fistulosa*, 7 *S. juncea*, 17 *S. multiradiata*, 1 *S. neglecta*, 2 *S. riddellii*, 4 *S. rugosa*, 3 *S. serotina*, and 8 *S. squarrosa*. Mature uredinia were formed in 15 to 17 days, and mature telia in about 2 months.

Ten sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus taeda* from Petersburg, Va.; Fayetteville and Lumberton, N. C.; Andrews, Clearwater, Columbia, Henry, and Sumter, S. C.; Macon, Ga., and Selma, Ala. Plants as follows were inoculated: 2 *Aster conspicuus*, 1 *A. chapmanii*, 2 *A. cordifolius*, 1 *A. dumosus*, 2 *A. geyeri*, 1 *A. laevis*, 3 *A. macrophyllus*, 3 *A. paniculatus*, 1 *A. novi-belgii*, 2 *A. undulatus*, 1 *A. vimineus*, 2 *Chrysopsis mariana*, 2 *Coreopsis major*, 5 *Elephantopus carolinianus*, 7 *E. tomentosus*, 1 *Helianthus angustifolius*, 2 *H. annuus*, 3 *H. divaricatus*, 1 *H. tuberosus*, 3 *Parthenium integrifolium*, 5 *Pharbitis purpurea*, 1 *Solidago bicolor*, 3 *S. canadensis*, 2 *S. chapmanii*, 4 *S. fistulosa*, 8 *S. juncea*, 8 *S. multiradiata*, 2 *S. riddellii*, 3 *S. rugosa*, 3 *S. serotina*, 2 *S. speciosa*, 3 *Vernonia angustifolia*, 5 *V. glauca*, and 6 *Verbesina virginica*. Of these plants, only those of *Solidago* were infected as follows: 3 *S. canadensis*, 7 *S. juncea*, 7 *S. multiradiata*, 2 *S. rugosa*, 2 *S. serotina*, and 2 *S. speciosa*. Mature uredinia were formed in 15 to 17 days and mature telia in about 2 months.

Six sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus pungens* from Sandy Hook, Md.; Bellville, Greenwood Furnace, and Mont Alto, Pa. Plants as follows were inoculated: 3 *Aster cordifolius*, 1 *A. geyeri*, 2 *A. lentus*, 1 *A. paniculatus*, 2 *A. undulatus*, 1 *Coreopsis verticillata*, 1 *Chrysopsis mariana*, 1 *Elephantopus tomentosus*, 2 *Helianthus occidentalis*, 7 *Solidago bicolor*, 3 *S. caesia*, 2 *S. canadensis*, 6 *S. multiradiata*, 1 *S. nemoralis*, 1 *S. riddellii*, 1 *S. speciosa*, 1 *S. squarrosa*, 2 *Vernonia glauca*, 3 *V. flaccidifolia*, and 2 *V. noveboracensis*. Of these plants, only those of species of *Solidago*

were infected as follows: 3 *S. bicolor,* 2 *S. canadensis,* 3 *S. multiradiata,* 1 *S. riddellii,* and 1 *S. squarrosa.* Uredinia and telia were produced in the usual time.

Four sets of inoculations were made with aeciospores from aecia collected on the needles of *Pinus resinosa* from Itasca Park, Minn. (collected by Mr. R. G. Pierce); Sharon, Vt. (collected by Dr. P. Spaulding); and Caledonia, Pa. Plants as follows were inoculated: 1 *Aster conspicuus,* 1 *A. cordifolius,* 1 *A. macrophyllus,* 1 *A. undulatus,* 3 *Campanula rapunculoides,* 1 *Convolvulus sepium,* 1 *Coreopsis verticillata,* 1 *Helianthus decapetalus,* 1 *Senecio aureus,* 1 *S. obovatus,* 2 *Solidago canadensis,* 6 *S. multiradiata,* 3 *S. riddellii,* and 1 *S. squarrosa.* Of these plants, only those of species of *Solidago* as follows were infected: 2 *S. canadensis,* 5 *S. multiradiata,* 1 *S. riddelli,* and 1 *S. squarrosa.* Uredinia and telia were produced in the usual time.

Two sets of inoculations were made February 26 and March 15, 1921, with aeciospores from aecia on *Pinus radiata* infected artificially October 7, 1920, with sporidia from teliospores from *Solidago bicolor.* The following plants were inoculated: 3 *Aster laevis,* 6 *Chrysopsis mariana,* 2 *Solidago bicolor,* 1 *S. monticola,* and 6 *S. multiradiata.* Only the plants of *Solidago bicolor* and *S. multiradiata* were infected, bearing mature uredinia in about 20 days, and mature telia in about 3 months. These inoculations were made at lower temperatures than those with aeciospores from species of pine, which were made chiefly in May and June. This explains the longer time required for the production of mature uredinia and telia.

One set of inoculations was made July 7, 1914,[18] with aeciospores from aecia collected by H. E. West of the Forest Service, on *Pinus contorta,* near Bozeman, Mont., June 25. The following plants were inoculated: 2 *Aster conspicuus,* 1 *A. cordifolius,* 2 *A. geyeri,* 2 *Coreopsis verticillata,* 2 *Elephantopus tomentosus,* 2 *Helianthus divaricatus,* 2 *Solidago canadensis,* 2 *S. juncea,* 2 *S. multiradiata,* and 2 *Vernonia glauca.* Of these plants, only those of *Aster conspicuus* and *A. cordifolius* were infected.

During 1914 to 1920, fifteen sets of inoculations were made, using urediniospores grown in pedigreed cultures from aecio-

[18] Hedgcock, G. G. L. c.

spore inoculations and taken from infected plants of *Solidago bicolor, S. canadensis, S. chapmanii, S. juncea, S. multiradiata, S. rugosa, S. sempervirens,* and *S. speciosa.* The following plants were inoculated: 3 *Aster conspicuus,* 2 *A. cordifolius,* 3 *A. geyeri,* 2 *A. laevis,* 5 *A. macrophyllus,* 1 *A. paniculatus,* 2 *A. pringlei,* 1 *A. undulatus,* 1 *Callistephus chinensis,* 6 *Chrysopsis mariana,* 2 *Euthamia graminifolia,* 3 *Elephantopus tomentosus,* 5 *Solidago bicolor,* 4 *S. canadensis,* 1 *S. chapmanii,* 1 *S. erecta,* 1 *S. fistulosa,* 1 *S. hispida,* 10 *S. juncea,* 23 *S. multiradiata,* 1 *S. neglecta,* 8 *S. riddellii,* 8 *S. rugosa,* 4 *S. serotina,* 3 *S. speciosa,* 7 *S. squarrosa,* 1 *Vernonia glauca,* and 2 *V. noveboracensis.* Of these plants, the following were infected, all bearing uredinia and some telia: 4 *Solidago canadensis,* 1 *S. hispida,* 7 *S. juncea,* 18 *S. multiradiata,* 2 *S. riddellii,* 3 *S. serotina,* and 2 *S. speciosa.* No plants of species of *Aster* were infected.

During 1915 to 1918, three sets of inoculations were made with urediniospores collected on *Aster paniculatus* near Harpers Ferry, W. Va., and on *A. longifolius* near Takoma Park, D. C. The following plants were inoculated: 1 *Aster divaricatus,* 1 *A. geyeri,* 4 *A. laevis,* 1 *A. longifolius,* 4 *A. macrophyllus,* 1 *A. vimineus,* 2 *Solidago juncea,* 1 *S. rugosa,* and 1 *S. serotina.* Only species of *Aster* became infected as follows: 2 *A. laevis* and 2 *A. macrophyllus.*

Two sets of inoculations were made on pine trees with sporidia from the telia of *Coleosporium solidaginis.* The first was made September 13, 1916, from telia collected by the writer on *Solidago rugosa* (no infected plants of *Aster* present) near Takoma Park, D. C., September 10. The following trees were inoculated: 2 *Pinus caribaea,* 3 *P. contorta,* 1 *P. coulteri,* 2 *P. echinata,* 1 *P. edulis,* 2 *P. mayriana,* 1 *P. montana,* 1 *P. palustris,* 1 *P. pungens,* 2 *P. rigida,* 2 *P. scopulorum,* 2 *P. serotina,* and 2 *P. taeda.* Of these trees the following were infected, bearing pycnia on or about December 21, 1916, and aecia about March 23, 1917: 1 *P. echinata,* 2 *P. rigida,* 2 *P. scopulorum,* and 1 *P. taeda.* The second set of inoculations was made in part from telia collected by the writer on *Solidago canadensis* near Chain Bridge, Va., September 28, 1920, and in part from telia col-

lected on *Solidago bicolor,* near Takoma Park, D. C., October 7 (no infected Asters present in either locality). Each collection was used in inoculations the day after collection. The following pines were inoculated: 2 *Pinus caribaea,* 3 *P. contorta,* 4 *P. coulteri,* 1 *P. edulis,* 1 *P. palustris,* 4 *P. radiata,* and 7 *P. rigida.* Of these, the following were infected, bearing pycnia on or about December 24, 1920, and aecia about March 15, 1921: 2 *P. caribaea,* 2 *P. coulteri,* 2 *P. radiata,* and 2 *P. rigida.*

No cultures could be made with pedigreed urediniospores from plants of species of *Aster* as none were infected in our inoculations with aeciospores. Urediniospores from infections on species of *Aster* in nature are apt to be mixed with those from infected species of *Solidago* which are nearly always present. In fact, the writer has usually found species of *Solidago* commonly infected in nature, and those of *Aster* rarely. Most of the species of *Aster* used in the inoculations were used because they were found infected in nature, and because of their known susceptibility.

The results from the inoculations are somewhat surprising. 132 plants of species of *Aster* and 241 of species of *Solidago* were inoculated with aeciospores from six species of pine from the eastern United States, viz., *Pinus echinata, P. nigra, P. pungens, P. resinosa, P. rigida,* and *P. taeda.* Of these, 142 plants of *Solidago* (59 per cent.) were infected and none of *Aster.* From inoculations with pedigreed urediniospores grown in the greenhouse on plants of species of *Solidago,* 19 plants of *Solidago* (25 per cent.) out of 77 inoculated were infected, but none of 19 plants of *Aster* inoculated were infected. These results may be interpreted in more than one way. It might be assumed that all the plants of *Aster* used were either from resistant species, or were not in proper condition for infection, neither of which is borne out by the facts, since many susceptible species were selected both of *Aster* and *Solidago,* and more than half of the plants were in splendid growing condition when inoculated. A more plausible explanation is that in the eastern United States we either have two races of *Coleosporium solidaginis,* the one on species of *Solidago,* the other on species of

Aster, or we have a second species of *Coleosporium* attacking species of *Aster*. The problem requires a further investigation before a definite solution is obtained.

Again, it must be noted that in the one experiment with aeciospores from aecia on *Pinus contorta* collected in Montana, 5 plants of *Aster* were inoculated, of which 3 were infected, and 6 plants of *Solidago*, all from the most susceptible species, were inoculated without infection. This indicates that this collection of aecia belonged to an *Aster* rust. The writer has collected the aecia of this rust on *Pinus contorta* in two regions in the west, one near Bozeman, Montana, the other in Estes Park, Colorado. The aecia in both cases were beyond maturity and immediately adjacent to the infected pine trees were infected plants of species of *Aster* which bore the uredinia of the *Coleosporium*. No infected plants of *Solidago* were found in either locality. In our inoculation experiments just given, 6 trees of *Pinus contorta* failed of infection when inoculated with the sporidia from the telia of the eastern form of the rust, although trees of *Pinus rigida* and *P. scopulorum* were abundantly infected from the same exposure under the same conditions. These results indicate that the western *Aster* rust may be distinct from the western *Solidago* rust which is probably identical with the eastern *Solidago* rust.

The aecia of *Coleosporium solidaginis* like those of *Coleosporium carneum* vary greatly in size, depending on the size of the needles of the species of pine infected. Those of *C. solidaginis* on pines with small needles, such are *Pinus echinata* and *P. pungens* (Pl. 23, fig. 1), are smaller than those on *P. rigida*, *P. scopulorum*, and *P. taeda* (Pl. 23, fig. 2). The pycnia and aecia of *Coleosporium solidaginis* are aggregated or clustered. Those of *C. carneum* (Pl. 23, fig. 3) on a given host are larger than those of *C. solidaginis* (Pl. 23, fig. 2), and are borne in more or less extended rows. The pycnia of *C. solidaginis* in color are grenadine-red to mahogany-red, those of *C. carneum*, orange-rufous to auburn or chestnut.

Coleosporium solidaginis has been reported as occurring naturally in its aecial stage upon 14 species of pine, chiefly in the

eastern United States.[19] It has been reported in the western United States only on *Pinus contorta* from Montana and Colorado.

Coleosporium solidaginis, in its form on *Solidago,* has been found occurring naturally in its uredinial and telial forms upon about sixty species of *Solidago,* in all regions of the United States, except in some of the southwestern states. It is now reported for the first time on the following species: *Solidago amplexicaulis, S. austrina, S. bootii, S. brachyphylla, S. celtidifolia, S. chandonnetii* Steele, *S. chapmanii, S. concinna, S. curtissii, S. decumbens, S. drummondii, S. erecta, S. fistulosa, S. glomerata, S. hispida, S. lancifolia, S. odora, S. petiolaris, S. pinensis* (Porter) Small, *S. pinetorum, S. pulverentula, S. purshii, S. rigida, S. rigidiuscula, S. speciosa, S. stricta, S. tortifolia, S. unigulata,* and *S. vaseyii.* The form occurring on species of *Aster* is known to occur on at least sixty species. In the eastern United States, it is now reported for the first time on the following species: *Aster acuminatus, A. concinnus, A. corrigiatus, A. hirsuticaulis, A. junceus, A. lowrieanus, A. oblongifolius, A. patulus, A. pringlei, A. schistosus* Steele, *A. spectabilis, A. tenuicaulis.* In the western United States it is now reported for the first time on *Aster fremontii, A. frondosus,* and *A. viscosum.* The form on the *Aster* has a range similar to that on *Solidago.*

Coleosporium solidaginis of the *Solidago* form in the eastern United States has been successfully inoculated by the writers from its telial stage on *Pinus caribaea* (*P. heterophylla*), *P. coulteri, P. echinata, P. nigra austriaca, P. radiata, P. rigida, P. scopulorum,* and *P. taeda,* and in its aecial stage upon *Solidago bicolor, S. canadensis, S. chapmanii, S. fistulosa, S. hispida, S. juncea, S. monticola, S. multiradiata, S. neglecta, S. pulverula, S. riddellii, S. rugosa, S. rupestris, S. serotina, S. speciosa,* and *S. squarrosa.*

The results of our inoculations indicate that in the eastern United States *Coleosporium solidaginis* is a rust attacking species of *Solidago* but not those of *Aster.* The *Coleosporium* on spe-

[19] Rhoads, A. S., Hedgcock, G. G., Bethel, E., & Hartley, C. Host Relationships of the North American Rusts, other than Gymnosporangiums which attack Conifers. Phytopathology 8: 324. 1918.

cies of *Aster* is apparently distinct from *Coleosporium solidaginis*. *Peridermium montanum* Arthur & Kern apparently belongs to a rust on *Aster* and if so is distinct from *Peridermium acicolum* Underw. & Earle, the aecial form of *Coleosporium solidaginis*.

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EXPLANATION OF PLATES

PLATE 22

Fig. 1. The pycnia and aecia of *Coleosporium ribicola* on the needles of *Pinus edulis* (× 2).

Fig. 2. The pycnia and aecia of *Coleosporium ipomoeae* on the needles of *Pinus palustris* (× 2).

PLATE 23

Fig. 1. Aecia of *Coleosporium solidaginis* on the needles of *Pinus pungens* (× 2).

Fig. 2. Aecia of *Coleosporium solidaginis* on the needles of *Pinus taeda* (× 2).

Fig. 3. Aecia of *Coleosporium carneum* on the needles of *Pinus taeda* (× 2).